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ABSTRACT

This paper describes a methodology for approaching the problem of migrating a course from the classroom to the World Wide Web. It proposes that there are four main learning modes in the classroom--traditional oral and visual (passive) presentation, student involvement in demonstration of the theory, student led practical exercises, and reference to written source notes or supplementary reference material--and that each of these can be successfully moved to a Web-based course. By way of illustration, this paper describes the "MPI On-Line" Web-based distance learning course developed at EPCC (Edinburgh Parallel Computing Centre, at the University of Edinburgh, Scotland). Students were provided with four different modes of access to the material in the MPI On-line course to correspond to each of the four identified learning modes: a multimedia slide show with animated slides and a spoken sound track; interactive demonstrations provided by browser applets to clarify the material presented in the slide show; student led exercises support by the EPIC (EPCC Interactive Courseware) environment; and supporting notes and reference material hyperlinked in to the rest of the material. When MPI On-line was run as a supported course for the first time in September 1997 it proved very successful and a great deal of positive feedback was received. (AEF)

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Towards a Method for Migrating Courses from the Classroom to the Web

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Abstract: In this paper we describe a methodology for approaching the problem of migrating a course from the classroom to the Web. We propose that there are four main learning modes in the classroom: passive presentation, high level interactive demonstrations, student led practical exercises and reference to written source notes, and that each of these modes can be successfully moved to a Web based course. By way of illustration we describe the *MPI On-line* Web based distance learning course developed at EPCC.

1 Introduction

The increasing size and importance of the Internet has led to growing interest in its use for training and education. For the last three years EPCC has been using Web technology to provide classroom and stand-alone courses [Westhead 96], [Westhead 97], [Minty and Westhead 97]. EPCC has a broad user base with complex and changing training requirements. Our course material must be relevant to hundreds of academic users, industrialists, visiting researchers, undergraduate summer students and in-house staff. In addition we are attempting to extend our training provision by developing a postgraduate diploma in High Performance Computing. This course would use Internet based distance learning as one of its main channels of teaching.

In developing such courses the importance of a model to provide a standard framework for on-line courses is clear. EPCC carried out a detailed study of our current classroom training methods to attempt to identify the key ways in which students gain information. We then looked at ways in which these methods could be translated into an on-line teaching environment. This process is described in the context of one of our distance course, *MPI On-line*.

2 The Structural Model

One of the biggest challenges for any distance learning course is how to keep the student's attention. For example, while detailed course notes complement the oral presentation in a classroom situation, notes were felt by past students to be less effective as the main form of presentation over the Web. This was attributed to the cumulative effect of eye-strain from reading a large amount of material from a computer screen, and the difficulty students had retaining interest while paging through a large document.

In order to develop a strategy for presentation of material in *MPI On-line* a detailed study was carried out of the teaching methods used in the classroom version of the course. Four distinct methods were identified.

1. Traditional oral and visual presentation.
2. Student involvement in demonstration of the theory.
3. Extensive and structured practical exercises.
4. Supplementary reference material.

In the development of the *MPI On-line* course we tried to incorporate these methods while presenting material via the Web. To do this we imposed the following model on the material presented by providing the students with four different modes of access to the material:

1. A multi-media slide show with animated slides and a spoken sound track.
2. Interactive demonstrations provided by browser applets to clarify the material presented in the slide show.
3. Student led exercises supported by the EPIC environment
4. Supporting notes and reference material hyperlinked in to the rest of the material.

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So, the seven course modules mixed presentations with demonstrator applets and a practical exercise, throughout which reference materials were made available.

3 EPIC

The *EP*cc *I*nteractive *C*ourseware (EPIC) is an experimental Web based package developed at EPCC. It allows users to interact with editors, compilers and their own exercise code all from a Web page viewed through conventional browsers like Netscape or Mosaic. Thus the student sees a consistent interface irrespective of where they are running the course. Exercises are linked to hypertext notes, standards documents and indeed any relevant material which can be made available on the Web.

The aim is to produce an interactive teaching environment which relieves the user of the cognitive burden of low level details like directory structures, file names and compiler flags. Instead they can concentrate on the course material.

EPIC was originally designed to support a particular type of programming course prevalent at EPCC. These courses are 2-3 day intensive courses each covering a different area of parallel computing with modules consisting of a short lecture with a follow on practical exercise. Such courses apply the Edit-Compile-Run cycle to make successive modifications to a piece of skeleton code. EPIC also provides additional value to exercises based on computational science simulations. In both cases the value of the system is to hide the underlying details and let the student focus on the course content.

A typical exercise page consists of three sections:

Exercise instruction: The instructions are laid out in steps so that the student is led, first through the main exercise, and then through any extra exercises.

Links: HTML links between the exercises and notes. Cross-referencing of sections enables students to find relevant information easily.

Control Buttons: Each page contains buttons to perform required tasks. Those most commonly used include:

Editor - Provides the student with an editor to use.
Make - Compiles the exercise code.
Run - Runs the exercise code.
Skip - View an example solution and, if required, replace the student's program with the example solution. This option is provided because many exercises build on the previous example. A student must have a working version of one exercise before moving onto the next.
Change - Alters exercise parameters, such as the preferred editor and the number of processes to use when running the exercise.
Clearup - Tidies up the file space and closes down any programs which are still running.
Help Enables students to ask their tutor for help.

EPIC is a client based system. It consists of a number of scripts that run on the user's machine which are invoked by the Web browser. Pressing a button on the browser causes a message to be sent to the EPCC web server, which interprets this message with a CGI script and sends back an EPIC command. This command is given a unique `epic` MIME type which identifies it to the browser as an EPIC command in the same way that a browser can identify a Postscript file. The browser then uses the external viewer mechanism which invokes the EPIC scripts locally, passing them the EPIC command.

A client side mechanism removes many of the security issues involved with programming exercises. Allowing unknown users to execute arbitrary pieces of code on your machines is obviously dangerous. Because EPIC's code is always executed on the clients machine there is no opportunity for them to engage in malicious attacks. It also means that in order to run the MPI course the client machine must have the MPI libraries installed.

3.1 An EPIC implementation of the MPI course

The MPI course was one of the first EPCC courses to use EPIC, and remains one of our core courses. Based on the EPCC course *Writing Message Passing Parallel Programs with MPI*, it was first released in Autumn, 1995. The main emphasis of this course was in the provision of on-line exercises although we have also found EPIC a useful tool in the

classroom. *MPI-Online* built on this core work by making use of new technologies such as streamed audio and Java applets to provide a more interactive presentation of the material.

4 Migrating MPI On-line

In this section we describe the development of the on-line teaching environment. The key task was to identify the activities that took place in the classroom course and finding ways to achieve the same effect on the Web.

4.1 Presentation of information

4.1.1 *Slideshow*

The multi-media slide show was intended to be the student's first contact with the material. It exposed them to both the general concepts, and a certain level of detail. It was our intention that the slide show should contain all the material essential for completing the exercises. In our MPI On-line course each slide show was between 10 and 20 minutes long, and although it would present itself, automatically flipping the slides in synchrony with the sound track, the student was able to stop the presentation at any point and replay bits that they found unclear.

As with the classroom course, *MPI On-line* the slide show is the key method of putting across information. Combining audio and visual presentation including animations and demonstrations (see [Practical Demonstrations]) allows information to be absorbed more easily. In *MPI On-line* the slide show is accompanied by a streamed audio presentation tailored to the slides.

The slides are constructed using a specially designed authoring package called the *Web Lecture System (WLS)* written by Rick Klevans which makes use of Progressive Networks' Real Audio technology.

4.1.2 Animations

During the classroom course, students are encouraged to take part in practical demonstrations of message passing. For example they pass envelopes around the room to indicate communications. In *MPI On-line* many of these demonstrations have been recreated using animated GIFs. These provide a useful method of presenting concepts and keeping students interested by providing a contrast to the slide show and soundtrack. Stills from the animations are shown in Figures 1 and 2.

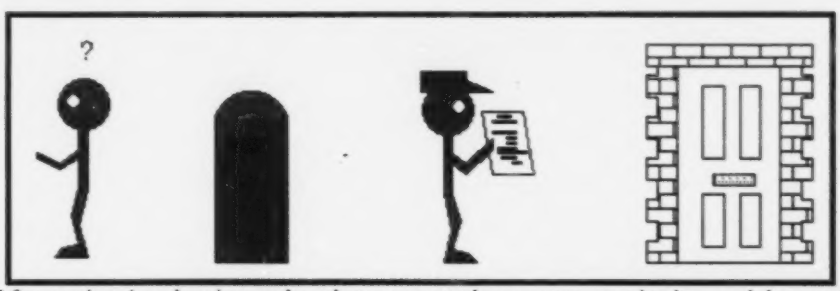

Figure 1: Still from animation showing analogy between asynchronous communications and the postal system.

4.2 Practical Demonstrations

In a classroom setting it is clearly much easier for students to ask questions and resolve areas which are unclear to them. In order to help clarify the students understanding and reinforce the information they have retained we built interactive examples that simulated some of the higher level concepts in the course. These allowed the students to explore their understanding of the concepts and discover problems before they are faced with the detailed programming exercises.

At this stage the aim is to ensure that concepts rather than their implementation are understood, so the exercises do not require the student to do any programming. Instead exercises are based around interactive examples and multiple choice questions implemented using Java applets. These were developed in collaboration with the SELLIC project.

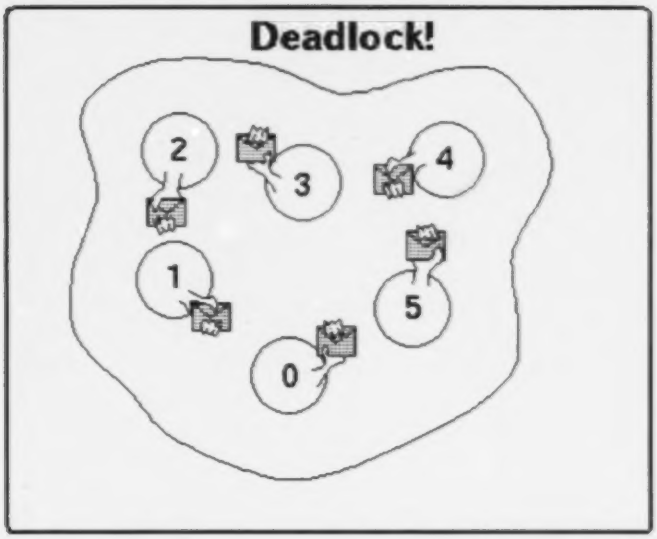

Figure 2: Still from animation showing deadlock of synchronous blocking communications

4.3 Practical Exercises

Courses developed within EPCC concentrate on the practical application of material being taught. A typical classroom session would consist of a 30-minute lecture followed by a 60-minute practical. With distance learning, the importance of practical reinforcement increases as exercises provide the only means for trainers to ensure that students have fully understood the material.

The EPCC MPI course has a large practical content. Exercise descriptions contain hyperlinks to the notes and references to the MPI standards document. In addition example solutions are provided to allow students to check their work. Email support is also available via the tutor button described below.

4.4 Reference Material

A version of the course notes and the MPI standard are provided. These can be viewed via the Web or printed as hardcopy, depending on the individual student's preference.

The course notes explore the same subjects as *MPI On-line* but in a more discursive manner than the session presentation. In addition, they cover a wider range of MPI routines than are examined in the course. However they do not contain comprehensive descriptions of the MPI routines themselves. That information has been left out with the intention of encouraging students to make full use of the MPI standard document. It contains information on all the MPI routines rather than the subset included in the EPCC course notes.

4.5 Student-Trainer Interaction

One of our goals in developing EPIC has been to provide a supportive structure in which students can easily present problems to a remote tutor for expert guidance. The tutor can 'virtually' look over students' shoulders to assist them with exercises.

The tutorial system automatically checkpoints the student's progress at set intervals during an exercise. If they face a problem they feel unable to resolve, the press of a button will package up the current exercise state and send it to an expert tutor. The tutor can then see a screen identical to the student's combined with a description of the problem and guide the student to a solution via e-mail.

To support the UK National Supercomputing Service, EPCC already maintains a sophisticated semi-automatic query system in which emails arrive at a central point and are directed to an appropriate member of staff. This provides an

ideal method for answering and monitoring *MPI On-line* queries. Throughout the first *MPI On-line* course in September 1997 course tutors were made available to deal promptly with any query arriving from an *MPI On-line* student.

5 Discussion

MPI On-line was run as a supported course for the first time in September 1997. It proved very successful and we received a great deal of positive feedback. The animations and interactive demonstrations were particularly effective.

On the other hand we were disappointed that the tutor button was barely used. We feel that there are four probable causes for this:

- The button was tucked away so that the user had to first press help in order to be presented with it.
- We arranged to have staff available to respond to tutor requests in under an hour. However we failed to advertise this sufficiently prominently so students could have been left thinking that they might not get a response from us for days.
- People inherently seek the easiest solution to their problems. In a classroom situation asking the tutor for help is often easier (though may be less educationally useful) than looking the answer up for oneself. In these situations the students may have felt it less effort to find their own help than describe it in an email and wait around for a reply.
- The students on this course run were all in institutions with expertise in these areas. There may have been people on hand at these sites who could help them directly with their problems.

In general the biggest weakness we see in the course at the moment is the limited amount of human interaction available to the student, in particular student-student interaction. The Internet provides exciting opportunities for group learning experiences, although it is not clear that these are appropriate for this material. However we certainly plan to increase the opportunities for students to interact with distant tutors and with each other.

6 References

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